

Factors Related to Gait Function in Post-stroke Patients

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Abstract. [Purpose] Gait function after a stroke is an important factor for determining a patient's ability to independently perform activities of daily living (ADL). The objective of this study was to elucidate the factors associated with gait function in post-stroke patients. [Subjects] Thirty-nine stroke patients (16 females and 23 males; average age 67.82 ± 10.96 years; post-onset duration: 200.18 ± 27.14 days) participated in this study. [Methods] Their gait function, motor function (Manual Muscle Test [MMT] and Brunnstrom stage), level of cognition (Mini-Mental State Examination score [MMSE]), and the Loewenstein Occupational Therapy Cognitive Assessment for the Geriatric Population [LOTCA-G]), and ADL (Korean modified Barthel index [K-MBI]) were assessed. [Results] The degree of gait function showed significant positive correlations with the following variables: MMT of the elbow, knee, ankle and wrist; Brunnstrom stage; MMSE; LOTCA-G subscores except motor praxis; K-MBI. Stepwise linear regression analysis revealed the Brunnstrom stage was the only explanatory variable closely associated with gait level. [Conclusion] Gait function of post-stroke patients was related to motor function, cognition, and ADL. In particular, there is a significant association between gait level and the Brunnstrom stages, reflecting the importance of monitoring the motor recovery of gait function in post-stroke patients.

Key words: Stroke, Gait, Brunnstrom stage

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INTRODUCTION

Gait function is an important factor that determines the degree of physical ability of post-stroke patients and their ability to perform independent mobility during activities of daily living (ADL)¹⁾. In previous studies, while 37% of stroke survivors were able to walk one week after the stroke, and 50% of those did regain gait function²⁾, 30% of patients with stroke were unable to walk again³⁾.

Other studies have reported that gait function is related to isokinetic torques of the paretic lower extremity⁴⁾. Some studies focused on simple walking speed and have demonstrated an association between cognitive function and motor performance⁵⁾. Therefore, the current literature suggests that gait is the combined result of muscle movement of the leg, the interlimb coordination pattern, and cognitive function⁶⁾.

In practice, these factors, which are important for the recovery of gait function following stroke, are critical for

developing therapeutic strategies designed to maximize participation and minimize disability⁷⁾. However, the single most influential factor determining gait function in post-stroke patients is not clear. Thus, the aim of the present study was to gain a more comprehensive understanding of the factors related to gait function in post-stroke patients.

SUBJECTS AND METHODS

This study used a cross-sectional design. The medical records of patients admitted to a rehabilitation hospital after acute stroke from October 2011 to October 2012 were retrospectively reviewed. The records of patients admitted due to traumatic brain injury, brain tumor, or neurodegenerative diseases were excluded. All patients underwent a standardized rehabilitation program consisting of physical and occupational therapy from the day after they were admitted. This study, a retrospective review of the patients' medical records, was approved by the Institutional Review Board of Kangwon National University Hospital (IRB No. 2013-12-004).

All assessments were evaluated by licensed physical and occupational therapists within the first week of admission. Gait level (GL) was assessed using six levels; GL1 indicates gait with complete dependence; GL2, maximum assistance; GL3, moderate assistance; GL4, minimum assistance; GL5, supervision required; and GL6, complete independence.

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Muscle strength was measured by Manual Muscle Test (MMT) with a score from 0 to 5⁸). MMT was determined based on the power of elbow flexion, wrist extension, knee extension, and ankle dorsiflexion. The Brunnstrom stage (BS) was used to assess the motor recovery of the paretic lower limb⁹) and was categorized as: BS1, flaccid; BS2, the development of synergy pattern with minimal voluntary movements; BS3, voluntary synergistic movement combined with hip flexion, knee flexion, and ankle dorsiflexion while in the sitting and standing positions; BS4, some movements, apart from synergy pattern, such as knee flexion exceeding 90° and ankle dorsiflexion with the heel on the floor in the sitting position were observed; BS5, independent movement apart from the basic synergic pattern; and BS6, isolated voluntary joint movements. The BS quantifies the function of motor control based on clinical assessment of movement quality.

The Mini-Mental State Examination (MMSE) was used to assess cognitive function. The MMSE is comprised of tests for orientation, memory, attention, calculation, language, and construction functions (total score between 0–30)¹⁰). The Loewenstein Occupational Therapy Cognitive Assessment for the Geriatric Population (LOTCA-G) was also used to assess cognitive function. It is composed of tests for orientation (0–16), visuospatial perception (0–28), praxis (0–12), visuomotor organization (0–24), thinking operation (0–8), memory (0–12), and attention (0–4).

Activities of daily living (ADL: total score between 0 and 100) were measured using the Korean version of the modified Barthel index (K-MBI). K-MBI evaluates 10 different areas of ADL: feeding, transfer, grooming, toilet use, bathing, mobility, ascending and descending stairs, dressing, and bowel and bladder control¹¹). The physical therapists evaluated gait and motor functions and the occupational therapists evaluated the levels of cognition and ADL.

Data were analyzed using SPSS for Windows version 18.0 (SPSS Inc., Chicago, IL, USA). Pearson and Spearman correlation coefficients were used to evaluate the relationships among the variables. Stepwise linear regression analysis was used to elucidate the explanatory factor associated with gait function. Statistical significance was accepted for values of $p < 0.05$. Data are presented as the mean with standard deviation (SD) values.

RESULTS

The clinical characteristics of the patients (16 females and 23 males; average age 67.82 ± 10.96 years; post-onset duration: 200.18 ± 27.14 days) are shown in Table 1.

The level of gait function showed significant positive correlations with the following variables; MMT of the elbow ($\gamma=0.658$, $p<0.001$), wrist ($\gamma=0.517$, $p = 0.001$), knee ($\gamma=0.574$, $p <0.001$), and ankle ($\gamma=0.557$, $p <0.001$); Brunnstrom stage ($\gamma=0.736$, $p <0.001$); MMSE ($\gamma=0.375$, $p =0.019$); LOTCA-G subscores ($\gamma=0.368-0.480$, $p <0.05$) except motor praxis ($\gamma=0.275$, $p =0.090$); K-MBI ($\gamma=0.634$, $p <0.001$) (Table 2).

Stepwise linear regression analysis revealed that the Brunnstrom stage ($r^2=0.500$, $F=46.308$, $p <0.001$) was the

Table 1. Clinical characteristics of the stroke patients

Variables	
Gender	
Female/Male (%)	16/23 (41.0/59.0)
Stroke etiology	
Infarction/ Hemorrhage (%)	25/14 (64.1/35.9)
Affect side	
Right/Left (%)	19/20 (48.7/51.3)
Age (years)	67.8±0.9
Post-onset duration (days)	200.1±27.1
Gait level (0–6)	3.6±1.5
MMT	
Elbow flexor (0–5)	3.3±1.4
Wrist extensor (0–5)	2.7±1.6
Knee extensor (0–5)	3.7±1.2
Ankle dorsiflexor (0–5)	2.7±1.6
Brunnstrom stage (0–5)	3.9±1.4
MMSE (0–30)	16.6±7.2
LOTCA-G	
Orientation (0–16)	8.1±5.1
Visuospatial perception (0–28)	21.0±6.2
Praxis (0–12)	9.1±3.0
Visuomotor organization (0–24)	14.3±5.8
Thinking operation (0–8)	3.6±2.1
Memory (0–12)	8.6±2.8
Attention (0–4)	2.6±1.1
Total score (0–104)	67.5±21.9
K-MBI (0–100)	46.0±20.0

MMT: Manual Muscle Test, MMSE: Mini-Mental State Examination, LOTCA-G: Loewenstein Occupational Therapy Cognitive Assessment for the Geriatric Population, K-MBI: Korean version of the Modified Barthel Index
Values are mean±SD

only explanatory variable closely associated with the level of gait function, indicating the importance of motor recovery in monitoring the level of gait function in post-stroke patients.

DISCUSSION

Better understanding of the factors that predict ambulatory function may assist with the development of individualized rehabilitation strategies for the various gait deficits of post-stroke patients⁶). Thus, we performed this study to elucidate factors related to the gait ability in post-stroke patients.

Paralysis after stroke is an important factor related to an abnormal gait pattern. Since paralysis after stroke leads to dependence in ADL, it should be an important target of post-stroke rehabilitation¹²). A previous study reported that the muscle strength of the paretic hip flexors and knee extensors is the most important factor for determining gait speed during comfortable and fast walking conditions¹³), and another study reported that walking independence shows a correlation with the muscle strength of the lower limb¹⁴). In

Table 2. Correlation coefficients of the measured variables with the gait level

Variables	γ
MMT ^a	
Elbow flexor (0–5)	0.658***
Wrist extensor (0–5)	0.517***
Knee extensor (0–5)	0.574***
Ankle dorsiflexor (0–5)	0.557***
Brünnstrom stage (0–5) ^a	0.736***
MMSE (0–30) ^b	0.375*
LOTCA-G ^b	
Orientation (0–16)	0.345*
Visuospatial perception (0–28)	0.392*
Praxis (0–12)	0.275
Visuomotor organization (0–24)	0.482**
Thinking operation (0–8)	0.423**
Memory (0–12)	0.356*
Attention (0–4)	0.438**
Total score (0–104)	0.473**
K-MBI (0–100) ^b	0.670***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

MMT: Manual Muscle Test, MMSE: Mini-Mental State Examination, LOTCA-G: Loewenstein Occupational Therapy Cognitive Assessment for the Geriatric Population, K-MBI: Korean version of the Modified Barthel Index

Analyzed by ^aSpearman's and ^bPearson's correlation coefficients

the present study, MMT of the affected lower limbs showed a significant correlation with gait level. Therefore, we suggest that approaches to improve the muscle strength of the paretic leg must be considered during stroke rehabilitation for the improvement of ambulatory function.

The Brünnstrom stages reflect post-stroke motor recovery⁹. A previous study using the Brünnstrom stages to measure motor recovery reported that the gait velocity of post-stroke patients showed a significant correlation with the status of motor recovery of the affected lower extremity¹⁵. Our findings demonstrate that the Brünnstrom stages are significantly correlated with gait level. Particularly, the Brünnstrom stages were the only remaining explanatory variable for gait ability in the regression analysis. These results imply that motor recovery influences physical functions such as walking. Impairment of muscle control or movement is the most common and widely recognized impairment caused by stroke. Therefore, stroke rehabilitation, particularly the work done by physical therapists and occupational therapists, largely focus on the recovery of motor impairment.

Gait is generally considered an autonomic process involving little or no higher cognitive input¹⁶. However, a recent study suggested that walking under usual circumstances may require attention and executive function¹⁷. Other studies have used MMES and LOTCA to investigate relationships between cognition and the functional outcomes of patients with stroke¹⁸. In particular, LOTCA-G

subscores were shown to have high correlations with most parameters of functional motor outcomes¹⁸. Therefore, we used MMSE and LOTCA-G to measure cognitive function. Our results show that gait ability is significantly correlated with the MMSE score and the LOTCA-G subscores, except that of motor praxis.

In this study, we investigated correlations between gait level and ADL performance to identify the effect of gait disturbance on the independence in ADL of patients with stroke. Our results show that there is a close correlation between gait level and K-MBI. This finding is consistent with previous studies¹⁹, and we believe that the results of this study support the results of a previous study²⁰. We found that as gait level increases, patients with stroke perform ADL more independently²¹ and participate more in social activities after discharge to home, even though they have a high risk of hospitalization²². This study had several limitations, and one of them was the small sample size. Therefore, these results cannot necessarily be generalized to all stroke survivors. In addition, this study exclusively investigated physical and cognitive factors affecting gait, but not psychological factors. Thus, we believe that future research is required to examine potential relationships between gait level and psychological factors such as depression, anxiety, or stress.

In conclusion, this study investigated the physical and cognitive factors associated with gait function in post-stroke patients. Gait function of post-stroke patients was related to muscle strength and motor recovery, cognition, and ADL. In particular, there was a significant association between gait level and the Brünnstrom stages. Therefore, the Brünnstrom stages should be assessed in post-stroke rehabilitation programs in order to enhance the improvement of gait ability.

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